

Collection and Treatment of Flowback and Produced Waters from Hydraulic Fracturing

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The Issue

- Oil and gas production using enhanced techniques is NOT new
- Hydraulic fracturing is NOT new
- Oil and gas production using hydraulic fracturing IS NEW in some geographies
- Public interest, awareness, and concern is high
- Many myths and misconceptions
- **The use of water and impact to water resources is a major concern**



Industry Challenges – Flow Back and Produced Water

- Increasing Transportation Cost
- Storage Cost – Frac Tanks, Impoundments, Tankage
- Flowback/Produced Water Processing
- Solid Waste Management
- Managing Total Cost
- Regulations Tightening
- Disposal Outlets are decreasing
- Best Available Technology

Goals: Reduce, Reuse, Recycle

The benchmark standard for professional water services



- Managing water and wastewater services for public authorities and industry
- Designing technological solutions and building and managing the facilities and systems required to deliver these services
- Construction, rehabilitation and maintenance of networks and associated infrastructure

2009 Revenue
\$18.1 billion

95,000
employees

Drinking water
services to
95 million people

Wastewater
services to
68 million people

Facilities managed
+5,260 water
+3,220 wastewater



The View from the Water Company

- Quantity- Need to address the supply issue- where is it coming from and is there enough?
- Cross contamination- how secure are the aquifers?
 - Well construction and expertise of drillers
- Quality- what is being put in the water, how well is it being treated, and what is it doing to the water resources?



Collection and treatment Issues

- Decentralized sources
- Rates variable, highest for short period during development
- No infrastructure in new areas
- transport and Discharge issues- footprint
- Challenging chemistry relative to effluent discharge options and disposal of solids



Fracking Fluid

- Over 90% water
- 9% sand
- Approximately 1% of “everything else”
 - Everything else can be salts, ethylene glycol, sodium, potassium carbonate, and a suite of proprietary mixes
- Primary quality concern: salts and solids
- Primary quantity concern: it takes a LOT of water!...but does it really compared to other uses of water? The golf course example



Flowback

- Early on, mainly fracking fluid and formation water
- Over time, more formation water
- Quality issues, decreasing frack chemicals and increasing percentage of formation chemistry
- Formation chemistry- salts, metals, NORM, organic compounds, etc.



How Much are we talking about?

An Example



- Marcellus Shale
 - Approx. 5,000,000 gallons of water used to frac each well
 - Approx. 1,000,000 gallons of water flows back over a 30 day period – (Flow Back Water)
 - After the well is put into production - The remaining 4,000,000 gallons plus any other source water is produced over the life of the well (Produced Water) – 10 bbls (420gal)/day/well
- <http://www.oerb.com/Default.aspx?tabid=242>

Solutions

- Modular approaches- package and mobile treatment plants
- Centralized treatment in local areas
- Reuse of treated water
- Highly efficient treatment (fast, cheap, low discharge, maximum water recovery)



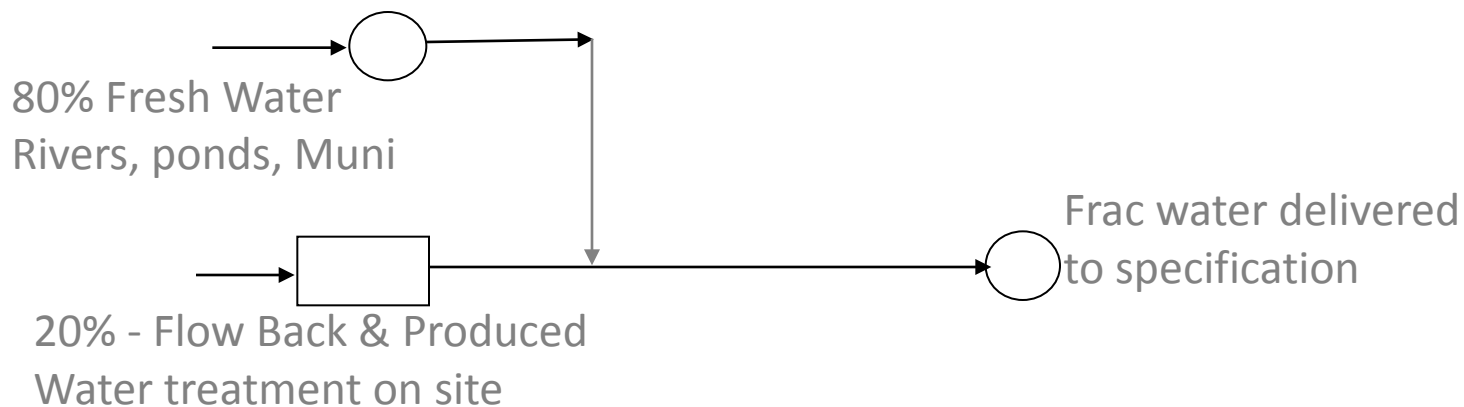
Treatment Levels

- Level 1 – Minimal Treatment - **Reuse**
 - Total Suspended Solids Removal – TSS – Physical Chemical Treatment
- Level 2 – Specific Ion Removal + TSS Removal - **Reuse**
 - Target removal of ions like Iron, Calcium, Barium, Strontium, Metals – Physical Chemical Treatment
- Level 3 – Meet Discharge limits for **Disposal**
 - Must remove Total Dissolved Solids (all ions)
 - Typical TDS levels in the Marcellus 120,000 ppm
 - Discharge limit <500 ppm
 - Typically Accomplished through application of thermal treatment when TDS levels >45,000ppm –(Evaporation/Crystallization Technology)
 - <45,000 ppm membrane technology is applicable



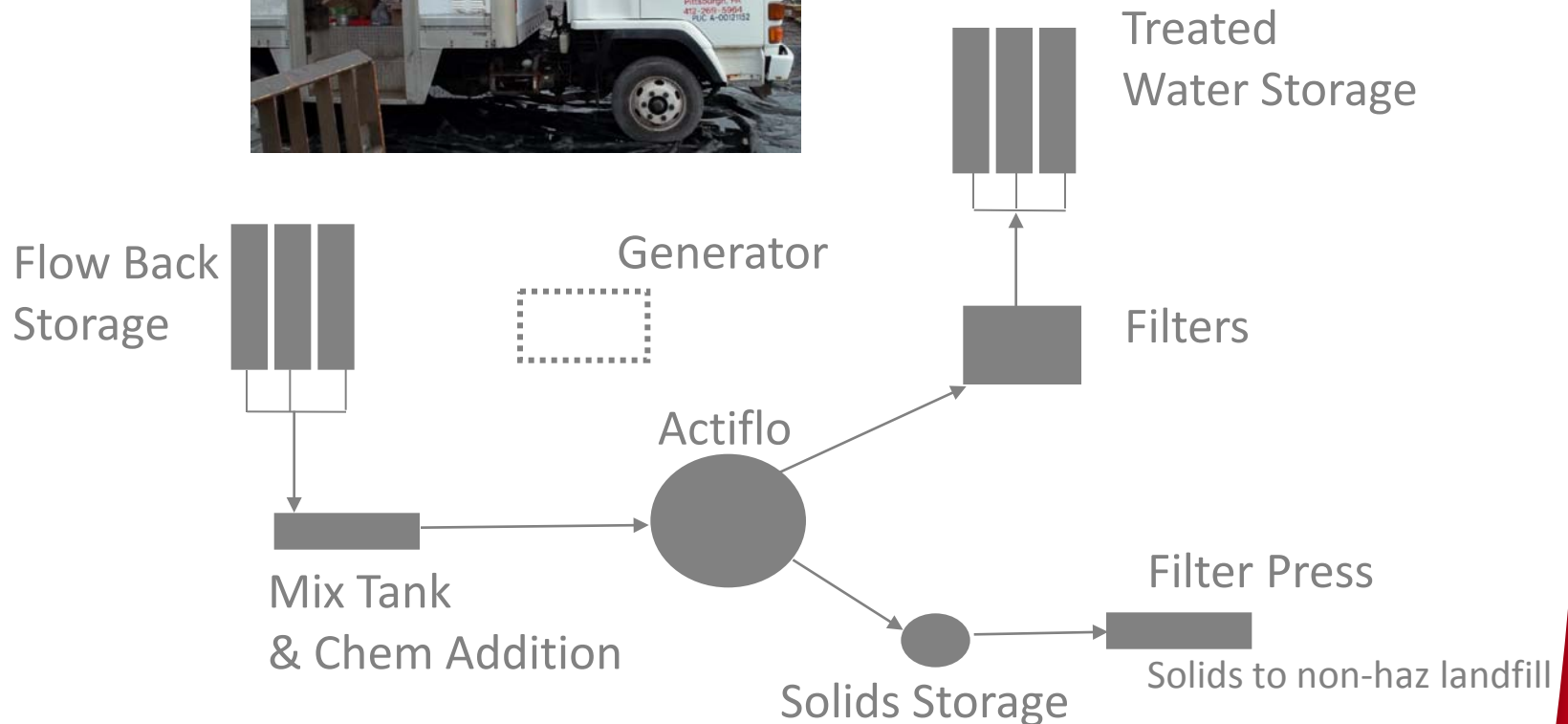
Total Water Management

- Includes
 - Collection
 - Transportation
 - Treatment
 - Mixing
 - Storage
- Reusing 100% of the flow back water and the majority of produced water



Case Study: Service Based

- On-going treatment in Marcellus with a major exploration company



Case Study: Current Treatment Results - Solids

- Challenge – Eliminate Hazardous Waste
 - Pass the paint filter test
 - Pass Toxicity Characteristic Leaching Procedure - TCLP
- Significant Cost Savings (Non-Haz vs Haz)



Shale Gas Plays, Lower 48 States



Source: Energy Information Administration based on data from various published studies
 Updated: May 28, 2009

Field Experience – ion removal

Case Study: Mobile Water System for Frac Reuse



- Enables Flowback Reuse
 - Flow Rate up to 10,000 bpd
 - Proven MULTIFLO™ Softening Technology
 - Associated Chemical Feed Skid
 - Fully Integrated System
- Removes Scale-Formers



Contaminant	Influent	Effluent
Calcium Hardness, ppm as CaCO ₃	8,000 – 40,000	<50.0
Magnesium Hardness, ppm as CaCO ₃	1,000 – 4,000	<50.0
Iron, ppm	25 – 200	<1.0
Manganese, ppm	5 – 10	<1.0
Barium, ppm	500 – 16,500	<10.0
Strontium	800 – 5,000	<10.0
Total Suspended Solids (TSS), ppm	100 – 1,000	<30.0

Oil Field - California

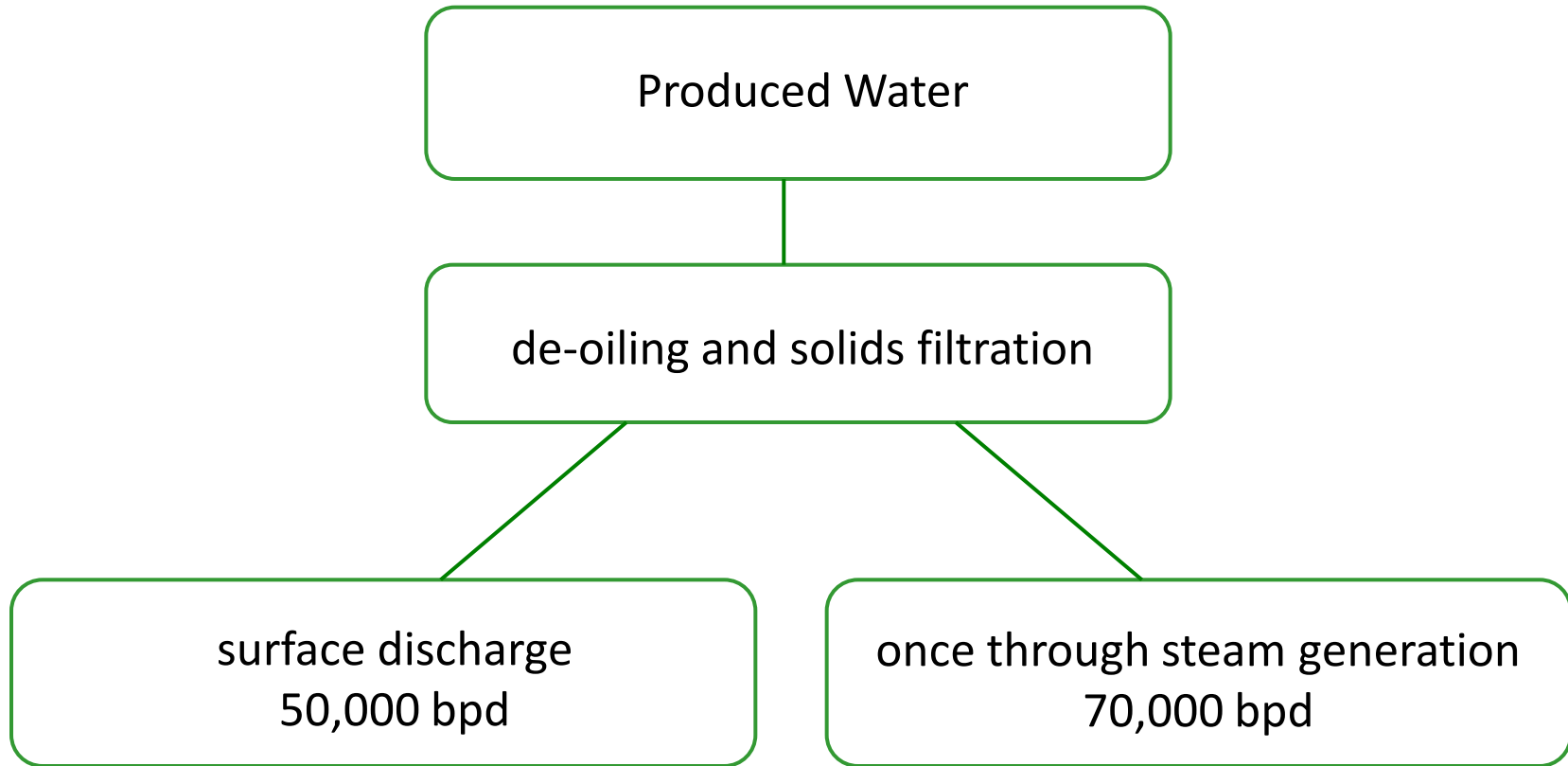


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Field Experience – TDS Removal
San Ardo Facility

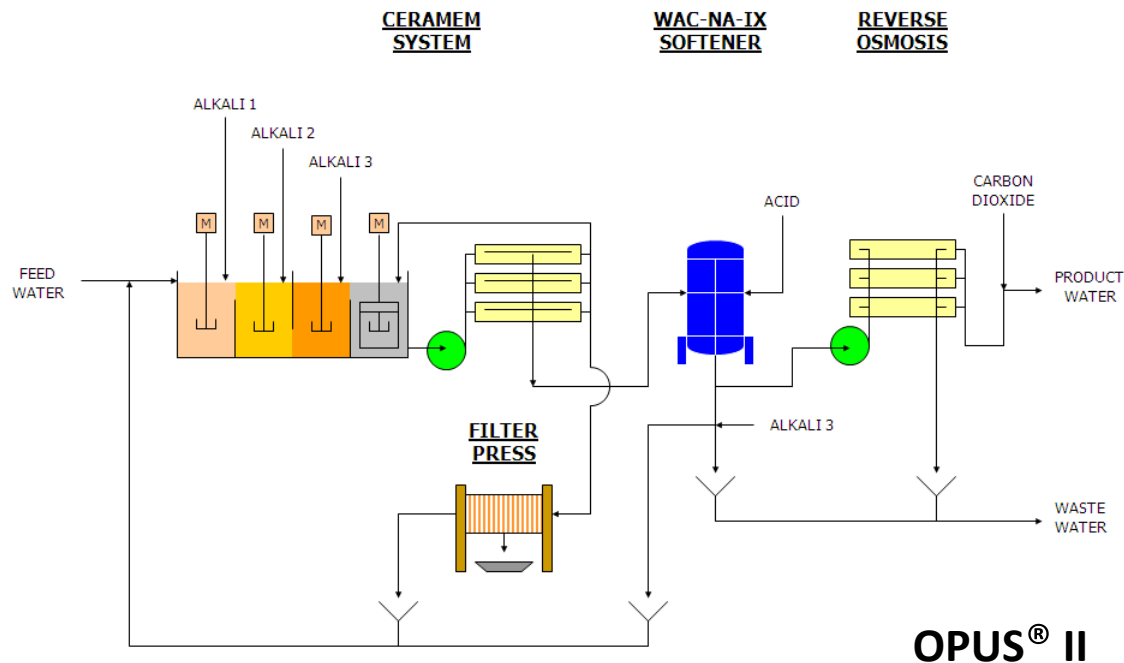


Principle



What is OPUS® II Technology?

- Optimized Pretreatment Unique Separation Process
- An innovative technology for sustainable reuse of industrial wastewater
- A Patented Technology covered by **US Patent No. 5,250,185**
- Key process advantage : high system water recovery rates



So what does all of this mean?

- Flowback and produced water is manageable
- There are various options to address differences in geography, chemistry, and producer requirements
- There is much activity in the development of technology and process to further improve the situation
- No one wants the water issue to be a barrier

